MODELING THE STRUCTURE AND FUNCTIONING OF THE ISRAELI MARINE CONTINENTAL SHELF ECOSYSTEM: INSIGHTS OF THE IMPACTS OF INVASIVE SPECIES AND FISHERIES

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Abstract

In order to characterize the structure and functioning of the Israeli marine continental shelf (ICS) ecosystem and assess main changes with time, we developed two food web Ecopath models representing the earlier 1990's and the 2008-2012. Results highlighted the increasing impact of invasive species on the ecosystem between 1990's and 2012. Fishing activities had noticeable impacts during both analyzed time periods. The ICS ecosystem shared common features in structure and functioning traits with other Mediterranean marine ecosystems

Keywords: Food webs, Levantine Basin, Invasive species, Fisheries

Biological invasions and fishing activities are currently considered two of the most important direct drivers of biodiversity loss and pose a major pressure on marine ecosystems (1,2). The ecosystems of the Israeli Mediterranean coast have undergone significant changes in recent decades mainly due to species invasions, fishing activity and climate change (3-4).

Ecopath food web models of the ICS for two periods of time (1990-1994 and 2008-2012) were developed in order to characterize the structure and functioning and to assess the impacts of invasive species and fishing activity on the ecosystem over time. The models were composed of 41 functional groups, ranging from primary producers to top predator species, and included eight invasive groups encompassing several crustacean and fish species with various trophic positions in the ecosystem. This represents the first attempt to study the south-eastern Mediterranean ecosystem using a mass-balance Ecopath model. Since there is a large amount of invasive species in the area, this represented a major modeling challenge and an important step forward in relation to previous applications of Ecopath that modeled invasive species in the Mediterranean Sea (5).

The analyses of the biomass and catch of invasive and natives species showed that during the last two decades the ecosystem notably changed, with the explosion of invasive groups and the depletion of some native groups (Fig. 1). This caused important changes in trophic flows between food-web components.
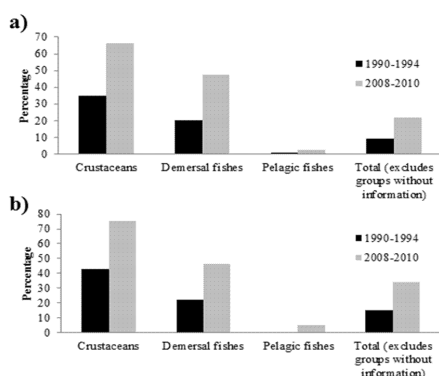

Fig. 1. Percentage of invasive species on the biomass (a) and catch (b) by different groups. Total biomass (excludes groups without information) includes all the groups with available information for to split between native and invasive species (fish, cephalopods and crustaceans (shrimps and crabs)). Planktonic groups, suprabenthos, polychaetes and benthic invertebrates are not included in this analysis.

Results highlighted a high impact of fishing activities during both analyzed time periods. For example, we observed high levels of gross efficiency of the fisheries and high requirements of primary production required to sustain the fisheries in both time periods. Additionally, although the total catch did not change, the % of discards increased dramatically (Table 1).

Despite productivity differences, the Israeli marine continental shelf ecosystem shares common features in structure and functioning traits with other Mediterranean marine ecosystems such as the important role of detritus, the dominance of the pelagic fraction in term of flows and the importance of the benthic-pelagic coupling.

Several hypotheses have been proposed to explain the extensive impact that invasive species have had on the ecosystem and the decline of native species (6,7). This includes, for example the cumulative impacts between invasive species, overfishing and climate change superimposed with the geological history and the environmental conditions of the Eastern Mediterranean Sea (6,7). Further developments of this work through spatial-temporal dynamic modeling will help to evaluate different hypothesis.

Tab. 1. Ecological indicators of the Israeli Mediterranean continental shelf (ICS) Ecopath food web model in two time periods.

Indicators	1990-1994	2008-2012	Units
Sum of all Consumptions (TQ)	155.30	150.38	$t \cdot km^{-2} \cdot year^{-1}$
Sum of all Exports (E)	188.65	184.26	$t \cdot km^{-2} \cdot year^{-1}$
Sum of all Respiratory Flows (TR)	57.79	56.35	$t \cdot km^{-2} \cdot year^{-1}$
Sum of all Flows to Detritus (TFD)	244.64	240.90	$t \cdot km^{-2} \cdot year^{-1}$
Total System Throughput (TST)	646.38	631.89	$t \cdot km^{-2} \cdot year^{-1}$
Total Biomass (excluding detritus) (TB)	8.69	8.80	$t \cdot km^{-2}$
Mean Trophic Level of the community (mTLco)	1.35	1.34	
Total Catches (TC)	0.94	0.93	$t \cdot km^{-2} \cdot year^{-1}$
Total landings	0.80	0.64	$t \cdot km^{-2} \cdot year^{-1}$
Total discards	0.14	0.29	$t \cdot km^{-2} \cdot year^{-1}$
Mean Trophic Level of the Catch (mTLc)	3.38	3.37	
Primary Production Required to sustain the fisheries (PPR, considering PP + detritus))	10.36	11.34	%
Gross Efficiency of the fisheries (GE)	0.004	0.004	
Mean Tranfer efficiency (TE)	18.90	19.00	%
Ecopath pedigree index	0.54	0.54	

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